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UNITED STATES
DEPARTMENT OF THE INTERIOR
HAROLD L. ICKES, SECRETARY

BUREAU OF MINES
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INFORMATION CIRCULAR

METHODS AND COSTS OF MINING AND CRUSHING GYPSUM AT THE MINE OF THE EBSARY GYPSUM CO., INC., WHEATLAND, N. Y.

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BY

E. J. LINTNER

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METHODS AND COSTS OF MINING AND CRUSHING GYPSUM AT THE MINE OF THE EBSARY GYPSUM CO., INC., WHEATLAND, N.Y. [1]

By E. J. Lintner[2]

INTRODUCTION AND ACKNOWLEDGMENTS

This paper is one of a series being prepared by the Bureau of Mines describing gypsum mining and crushing methods and costs at various operations throughout the United States. These papers are designed to dissemminate technical information regarding methods used. The cost tabulations represent local operating expenditures only and not total production costs. It is recognized that publication of total production costs may in many instances cause embarrassment to the individual operator as well as to the industry as a whole; on the other hand, operating costs are essential to the technical discussion and study of the methods employed. The attention of the reader is specifically called to this differentiation in order that no misunderstanding of the scope of the cost tabulation shall ensue.

The following report deals specifically with the mining and primary crushing methods employed at the plant of the Ebsary Gypsum Co., Inc., Wheatland, Monroe County, N. Y. This company is capable of maintaining a maximum yearly production of 220,000 tons of crushed gypsum, thereby ranking as one of the largest gypsum operators of the State. The methods and practices employed typify the standard methods followed by gypsum producers in western New York State. The bed of gypsum mined lies only 35 feet beneath the surface and is above average thickness for this vicinity.

The mine and plant are near the village of Wheatland, approximately 15 miles southwest of Rochester. Rail connections are had with the Baltimore & Ohio R. R. (See fig. 1.)

The author wishes to thank C. M. Winslow, plant manager, and his organization for their splendid cooperation in assembling these data.

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[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 6971."

[2] Associate mining engineer, Bureau of Mines.

BRIEF HISTORY AND EARLY DEVELOPMENT OF DISTRICT

Gypsum was discovered in New York State in 1792 by William Lindsay of the town of Camillus, Onondaga County. Originally the early settlers quarried it, gound it in local grist mills, and used it as fertilizer or land plaster in the immediate vicinity. The opening of the Erie Canal in 1826 greatly increased the market for land plaster. Additional deposits were opened to take care of the demand and the industry grew rapidly.

Gypsum was discovered in Monroe County in 1811 quite by accident. In this year, Peter Sheffer, one of the first settlers, began to erect a grist mill on the north side of Allen's Creek at a place now known as Garbutt, about 2 miles east of Wheatland. He promised a neighboring farmer, John Garbutt, that he would grind a load of gypsum for him in his new mill immediately after the stones were set in place. As the mill neared completion, Garbutt set out for Cayuga County, a distance of approximately 70 miles, to obtain a load of crude gypsum from the quarries there. In his absence, one of the workmen uncovered a ledge of gypsum while excavating the millrace for the grist mill[3]. This important discovery immediately led to further search, and soon other ledges were disclosed nearby on both sides of Allen's Creek.

The farmers in the immediate vicinity were rather slow to use land plaster, and it was not until 1818 that they manifested any special interest in it. Shortly thereafter a special mill was erected, in which, during 1820-1830, several hundred tons of gypsum were ground to land plaster.

A short while later Garbutt acquired this mill, and for over 100 years thereafter this family was identified with the gypsum industry.

The reports of the first geological survey of New York (1836-1841) mention gypsum quarries in Monroe, Ontario, Cayuga, Onondaga, and Madison Counties. Of the many localities listed in these first reports of the survey, the village of Wheatland alone has maintained its importance to the present time.

The Ebsary Gypsum Co., Inc., was organized in 1911 and acquired the properties of the Monarch Plaster Co. and the Consolidated-Wheatland Plaster Co. in 1921. The plant of the Consolidated-Wheatland Plaster Co. was operated until 1924, when it was abandoned. Thereupon, a modern clacining plant was erected. The plant is situated on the south side of Allen's Creek just west of Wheatland station. Additional buildings and departments were added later, so that today this company manufactures a complete line of gypsum products and ranks among the leaders in the gypsum industry of the United States.

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[3] Slocum, Geo. E., Wheatland-Monroe County, N. Y. A Brief Sketch of Its History: 1908, p. 48. (Printed by Isaac Van Hooser, Caledonia, N. Y.)

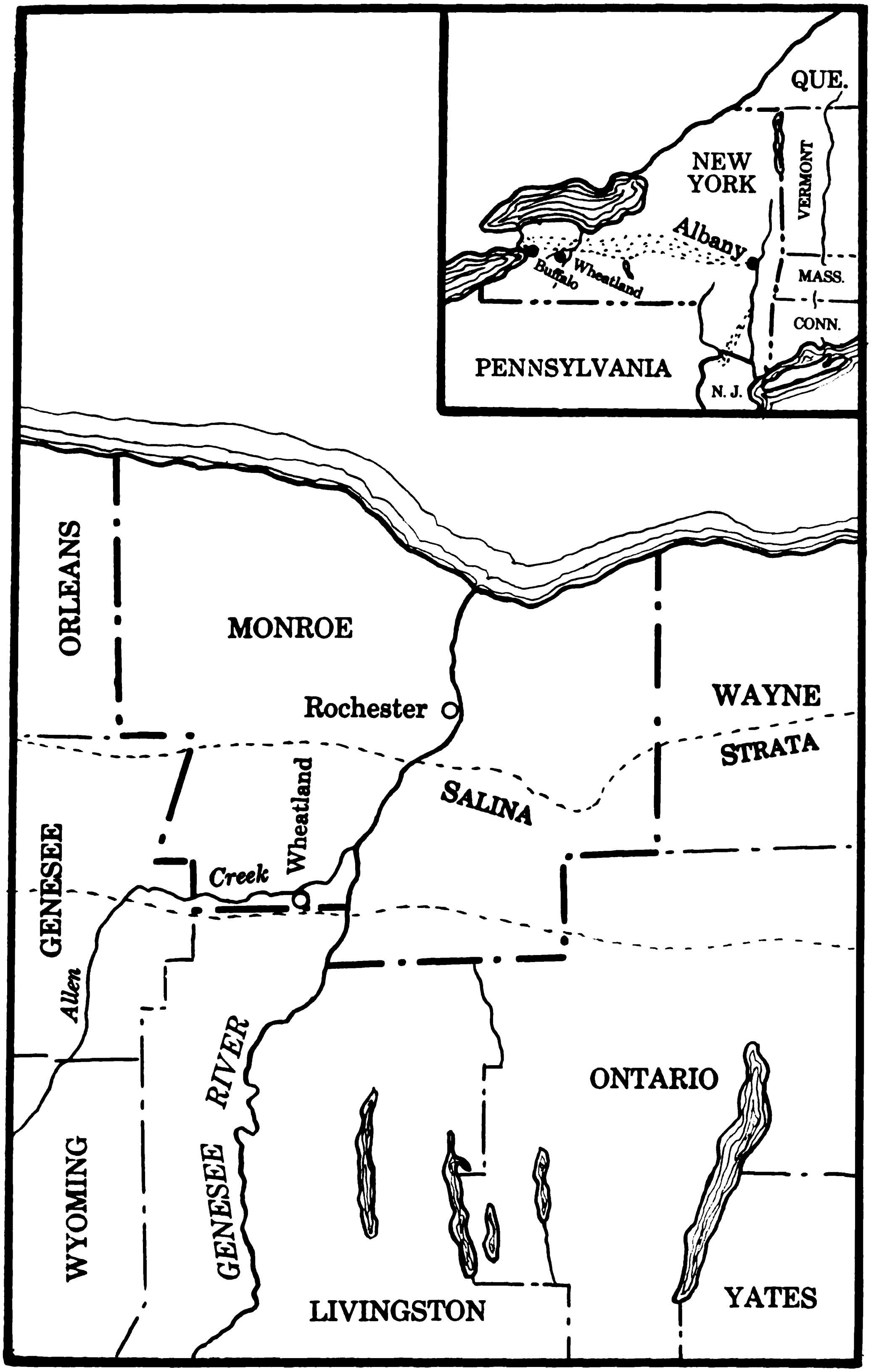

Figure 1.—Gypsum belt, Monroe County.

GEOLOGY

The commercial gypsum deposits of New York State occur in the Salina formation of the Silurian system. The Salina strata occupy two separate areas within the State. (See fig. 1.) The largest and commercially most important area extends due west from Albany County to the Niagara River in a belt of varying width. Throughout this area the Salina is mainly a shale formation and is divisible into five members. These are, in descending order, the Bertie limestone, the Camillus shale, the Syracuse salt, the Vernon shale, and the Pittsford shale. The workable gypsum beds are found at different horizons in the Camillus member, which consists of a considerable thickness of soft shale containing intercalated layers of magnesian limestone.

The Salina strata in central New York have a slight but persistent dip to the south ranging from 40 to 50 feet per mile. The main part of this belt consists of a broad shallow syncline whose axis runs north and south.

The topography of the county is rolling to flat. The lands are drained by Allen's or Oatka Creek, which flows in an easterly direction and empties into the Genesee River south of Rochester.

PHYSICAL CHARACTERISTICS OF GYPSUM AND ENCLOSING ROCKS

The Camillus shale ranges in color from gray to olive green, while in some places it is red. The thickness of the shale and gypsum beds averages 300 feet in the central part of this belt.

There is no continuous seam or bed of gypsum in the Camillus member, it being distributed in the form of veins, lenses, and broad beds that succeed each other along the strike and dip. Thus, the commercial deposits are well-defined and considerable distance may occur between adjacent deposits that is entirely barren of gypsum. The thickness of the gypsum beds ranges from a few inches to 5 feet or more[4]. The various beds and lenses vary also in purity. The Salina formation, except for a few feet at the base, is devoid of fossils.

The top beds of gypsum usually are much thicker and lighter in color near the outcrop. Moving down along the dip, the beds become thinner and darker while the gypsum itself grows harder and considerable anhydrite is present.

The Camillus beds cross Monroe County from east to west in a belt ranging in width from 2 to 3 miles. The most valuable deposits are found in the vicinity of Wheatland. Here they are exposed for a distance of several miles along Allen's Creek in two beds separated by 1 to 25 feet of limestone. The upper bed is above the stream level and ranges from 5 to 8 feet in thickness, while the lower bed is about 6 feet thick. The upper bed is the one mined by the Ebsary Gypsum Co., Inc. The gypsum in this bed is compact and brown. In places it contains a small amount of selenite and satin spar. The lower part of the bed is 8 to 18 inches thick, lighter in color than the top portion, and is also purer and much harder.[5]

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[4] Stone, R. W., and others, Gypsum Deposits of the United States: Geol. Survey Bull. 697, 1920, p. 194.

METHODS OF PROSPECTING AND EXPLORATION

At the time the property was acquired a series of test holes was drilled with a 2-inch-diameter shot core drill. These holes were placed at irregular intervals, no definite or systematic spacing having been followed. The log of a typical test hole is as follows:

	Feet	Inches
Clay	25	10
Hardpan	4	0
Gypsum	7	0
Limestone	25	2
Gypsum	6	0
Limestone	7	0
Gypsum	4	0
Limestone	6	0
Gypsum	8	0
Limestone	1	0
Gypsum	9	0
	103	

Hole stopped in Gypsum.

This hole is on high ground several hundred yards south of the main slope, which accounts for the fact that the top bed has such a large cover.

METHODS OF SAMPLING AND ESTIMATING TONNAGES AND VALUES

The gypsum bed mined is exceedingly uniform in character and extent and no anhydrite is present. For this reason it is not necessary to take mine samples for chemical analysis. However, samples of the finely ground gypsum or landplaster are taken at stated intervals for chemical analysis. The analysis of the landplaster is as follows:

	Percent
Loss in ignition	26.74
Carbon dioxide (CO_2)	12.25
Iron and aluminum oxide (R_2O_3)	.60
Acid, insoluble	3.93
Calcium oxide (CaO)	30.43
Magnesium oxide (MgO)	5.14
Sulphates as SO_3	31.54
Alkali metals, chlorides, and organic matter	1.62
Total silica (SiO_2), free and combined	2.83
Al_2O_3 from acid insoluble	.54

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[5] Newland, D. H., The Gypsum Resources and Gypsum Industry of New York: New York State Museum Bull. 283, 1929, p. 100.

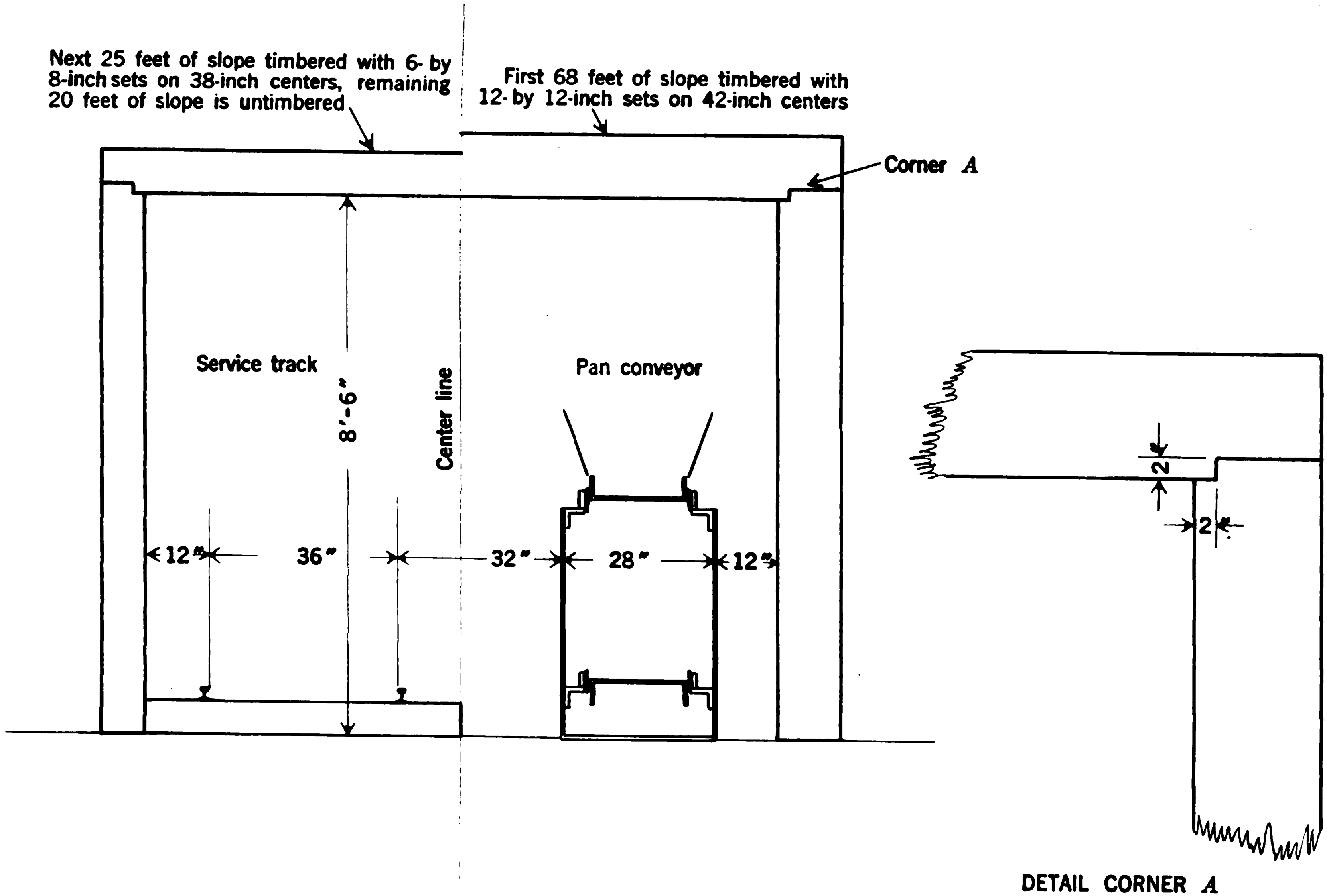

Next 25 feet of slope timbered with 6- by 8-inch sets on 38-inch centers, remaining 20 feet of slope is untimbered
First 68 feet of slope timbered with 12- by 12-inch sets on 42-inch centers
Corner A
Service track
8'-6"
Center line
Pan conveyor
12"
36"
32"
28"
12"
2
2
DETAIL CORNER A

Figure 2.—Slope timber sets.

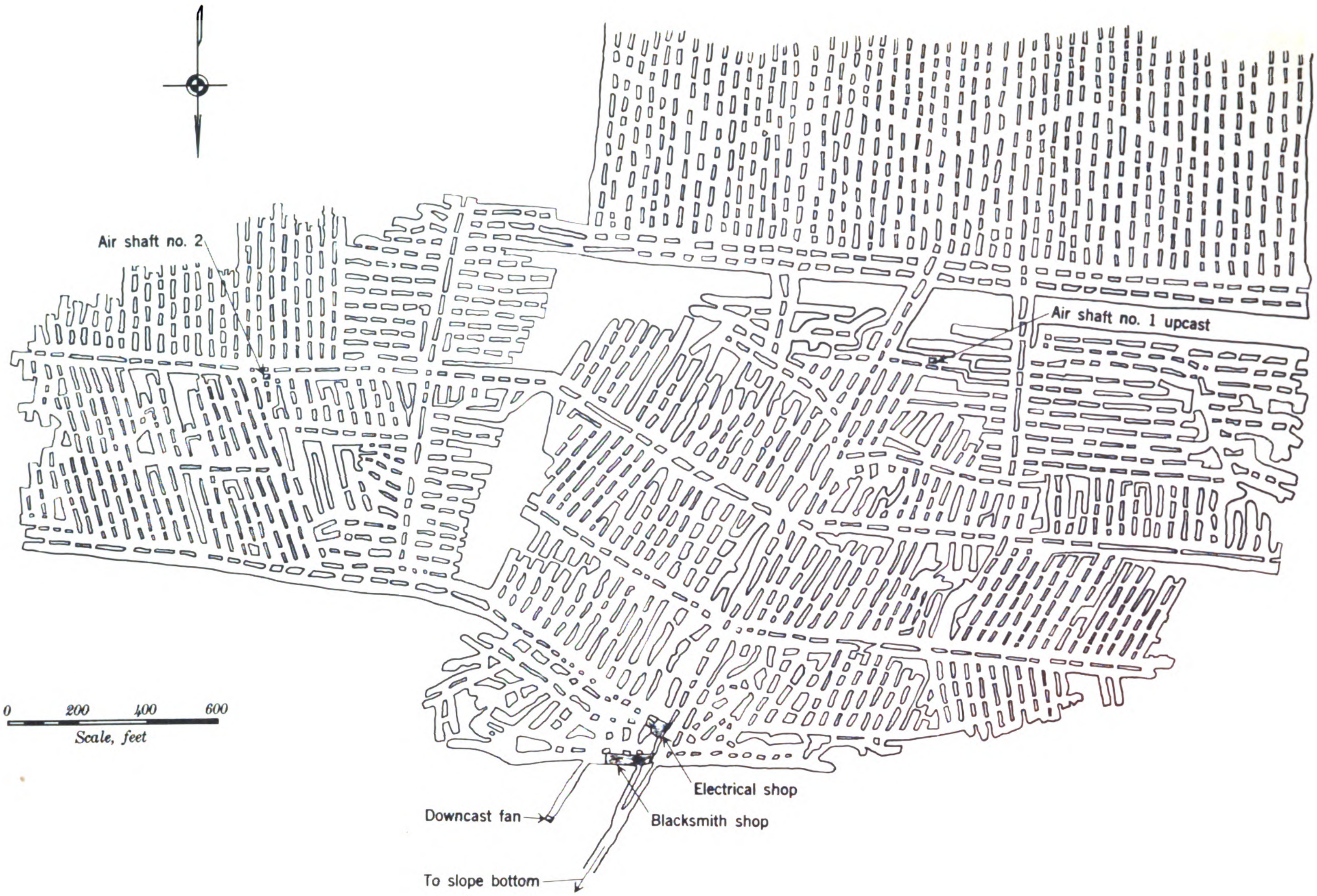


Figure 3.—Mine workings.

Translation of above results

	Percent
Gypsum ($CaSO_4 2H_2O$)	67.82
Calcium carbonate ($CaCO_3$)	17.20
Magnesium carbonate ($MgCO_3$)	10.75
Free silica or quartz (sand)	1.32
Clay, including iron oxide	1.35
Feldspar	1.74
Soluble sodium, potassium compounds and organic matter	1.62

CHOICE OF METHOD

The top bed of gypsum lies approximately 35 feet beneath the ground elevation of the crushing plant. It is reached by a 26-percent slope, 10 feet wide by 113 feet long. Three-piece, framed, square-cut, untreated timber sets line the slope for a distance of 93 feet. The mill buildings are directly above the slope, so that the first 68 feet is timbered with sets made of 12- by 12-inch oak pieces set on 42-inch centers, while the balance of the slope is timbered with 6-inch by 8-inch members set on 38-inch centers. Figure 2 shows the style of framing used.

The mined rock is sent to the surface by means of a pan conveyor. The slope is sufficiently wide inside the timber sets to permit placing a service track beside the conveyor, over which all supplies and materials are taken into the mine.

The gypsum bed lies practically horizontal, thus making the room-and-pillar system of mining an ideal method to use. Triple entries are employed, and these, together with the rooms, are driven 24 feet wide on 40-foot centers. Crosscuts 20 feet wide are placed on 50-foot centers, leaving pillars 16 by 30 feet. Figure 3 shows the mine workings.

The gypsum averages 6 feet in thickness and is composed of two distinct beds separated by a thin parting. The top bed varies from 4 feet 6 inches to 5 feet 4 inches in thickness while the botton bed varies from 8 to 18 inches. They are mined by the "underhand" or "bench stope" method. Flat holes are placed in the top bench while short vertical holes are drilled in the bottom bench. The lower bed is so hard that electric drills cannot be used advantageously, and jackhammers must be used. Both beds are shot at the same time and loaded together into the mine cars.

The roof and floor are composed of flat smooth limestone, so that little track grading is required in the rooms and entries.

No pillars are being removed at present, but these will be recovered before the mine is abandoned.

At the time this study was conducted the mine was producing 500 tons in one 8-hour shift. Thirty-nine productive and 11 nonproductive men are required inside the mine to maintain this tonnage. This is the equivalent of 9.80 tons per man shift, or 1.09 tons per man hour.

MINING METHODS

Drilling

Mounted electric rotary drills are used in drilling the top bench and jackhammers are used in the bottom.

The electric rotary drills are extremely simple and rugged in construction. They consist of a small pinion mounted on the armature of a 3-horsepower motor that drives an internal, machine-cut, bronze gear 12 inches in diameter through the center of which passes a hollow feed bar that contains the drill steel. The armature is housed in a sturdy, two-piece, cast-steel body having the pole pieces and hollow shaft bearings case integral. The hollow feed bar is 2 inches in diameter by 5 feet in length and has 10 threads per inch. A 3-1/2-inch-diameter chuck containing two setscrews for clamping the drill steel is mounted on the forward end of the feed bar.

Movement of the feed bar is controlled by means of a split bronze feed nut 3-1/2 inches long and a friction clutch 4 inches in diameter mounted on the forward end of the drill housing. Releasing the friction clutch stops the forward movement of the feed bar but allows it to rotate as before. Figure 4 shows the drill and column.

The drill is mounted on a saddle clamp that can be fastened readily to a 3-1/2-inch- diameter steel column 48 inches long. Double adjusting screws 2 inches in diameter by 12 inches long on a cross member placed on the lower end of the column, permit the member to be tightened securely into position. A second adjusting screw 2-1/2 inches in diameter by 18 inches long can be set inside the top of the hollow steel column if additional height be desired.

A portable cable reel 12 inches in diameter by 16 inches long contains 150 feet of rubber-insulated duplex cable, which carries the current to the drill. Plug terminals on the ends of the cable are used as switches to control the actual operation of the machine.

Twisted drill steel 1-1/2 inches in diameter by 8 feet 6 inches long, having 8 turns per foot, is used with a full diamond-point bit 1-3/4 inches in diameter. The bar of drill steel is inserted in the hollow feed bar and held in place by the two setscrews in the feed-bar chuck. Each driller has included in his drill outfit a small hand emery wheel mounted on a 2- by 6-inch by 6-foot wood post, by which he can sharpen his drill steel. This is set upright near the working face by wedging it between the roof and floor.

A contract crew consists of a driller and two loaders. The driller

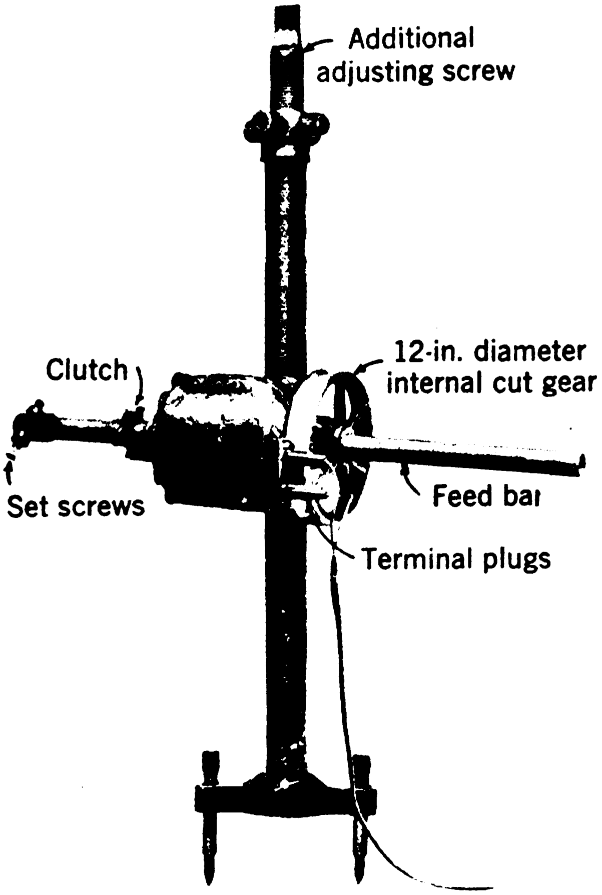
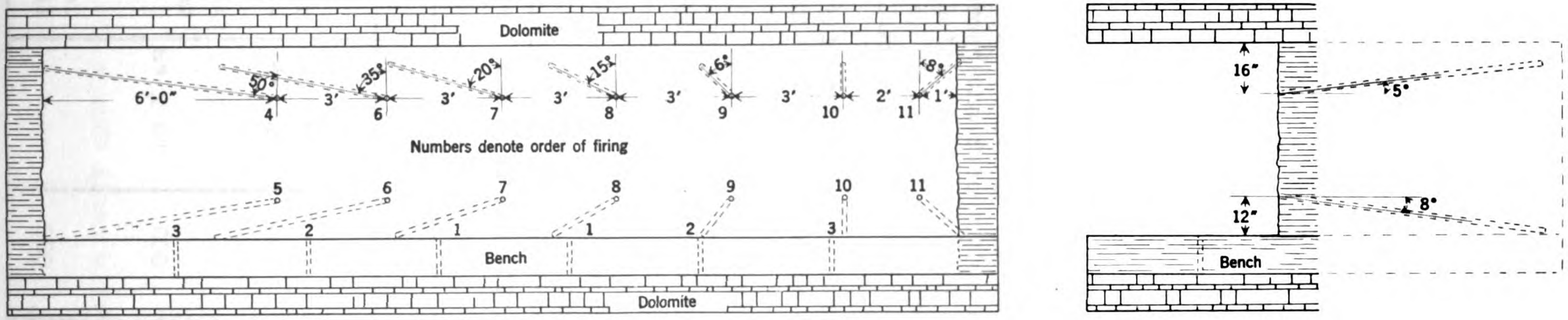
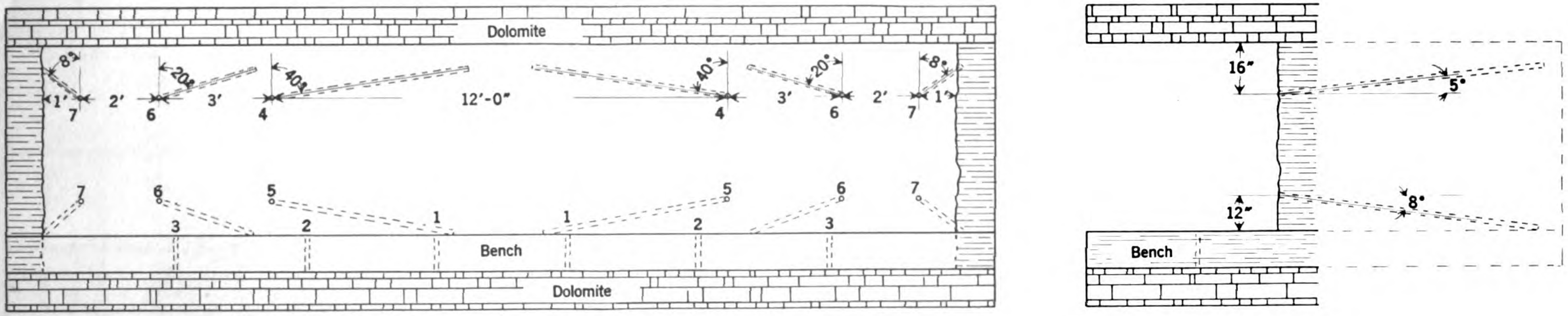


Figure 4.—Electric rotary drill.



LINE-HOLE METHOD



CENTER-CUT METHOD

Figure 5.—Drill rounds.

usually calls upon the loaders to assist him in mounting the drill. The column is placed about 4 feet behind the face and the drill is mounted on the clamp. One top and one bottom hole are drilled from this set-up. Upon completion of this pair of holes, the column is moved into a new position for the next pair of holes.

The top holes are collared about 16 inches below the roof and are inclined at an angle of 5° above the horizontal. The bottom holes are collared 12 inches above the bench and are inclined at an angle of 8° below the horizontal. Holes 1-3/4 inches in diameter usually are drilled to a depth of 8 feet. The actual drilling speed in both top and bottom holes is 21 inches per minute.

Two different arrangements of drill holes are used. Also, the number of holes drilled in each face varies from 12 to 14.

In the first method a center cut is made, followed by two or three pairs of slab holes. In the second method a series of slab holes is drilled across the face with a side cut. The method used as well as the number of holes drilled depend upon the condition of the face and whether any vertical slips or breaks are present. The second method generally is used. Figure 5 shows each of these drill rounds in detail.

In drilling the bottom bench, from 6 to 8 vertical holes 1-3/4 inches in diameter are equally spaced across the room in a single row about 2 feet in front of the face. The drilling speed of the jackhammers will average 26 inches per minute, the holes being drilled dry. Portable air compressors supply air at a pressure of 90 pounds at the receiver. Each compressor car carries a complete drill outfit, consisting of one jackhammer, 50 feet of 1-inch-diameter, wire-wrapped, air hose and from 4 to 6 bars of 7/8-inch hexagonal hollow drill steel 24 inches long. Detachable four-point bits having 1-3/4-inch cutting edges are used. Two drill outfits are used consecutively by the 11 drillers. A third outfit is held in reserve in the shop near the foot of the slope. The size and capacity of these three compressors are as follows:

Type	Size cylinder	R. p. m.	Maximum Pressure	Drive	Motor h. p.	Size receiver
2-cylinder vertical--	4-1/2" x 4-1/2"	500	150	Belt, 6" x 6'-0"	10	Single-receiver, 30" diameter, 36" long.
1-cylinder vertical	6" x 6"	600	150	6" x 5'-6"	12	Single-receiver, 30" diameter, 36" long.
2-cylinder horizontal	------	860	125	Direct-connected	10	Double-receiver, 12" diameter, 84" long.

After completing a round of holes in both the face and bench the driller moves the drill outfit to a crosscut in the rear and spends the balance of the shift preparing stemming and primers and loading the holes.

A round of 14 holes in the face and 8 holes in the bench will produce approximately 60 tons of gypsum. This is the equivalent of 0.5 ton per foot of hole drilled.

The drillers are paid on a contract basis at a rate of 20 cents per ton. They are required to furnish explosives, which are obtainable from the company.

Blasting

Special, low-density, 20-percent-strength, ammonia dynamite, size 1-1/8 inches by 8 inches, is used with no. 6 caps and double-taped safety fuse. The primer is made by lacing the fuse diagonally through the stick of dynamite and then inserting the cap lengthwise in the center of the stick. The primer is always placed last in the holes. Stemming shells 1 inch in diameter by 15 inches long are rolled from newspaper and filled with drill cuttings at the face as needed.

In loading the top bench, five sticks of dynamite with three stemming cartridges are placed in the top holes and nine sticks of dynamite and three stemming cartridges in the bottom holes. Two sticks of dynamite and enough stemming to fill the hole completely are placed in the vertical holes in the bottom bench. The fuse is cut in such lengths as will cause the holes to fire in the order indicated by the numbers on figure 5.

The tamping bar is made of hard wood and is 1-1/4 inches in diameter by 8 feet 6 inches long.

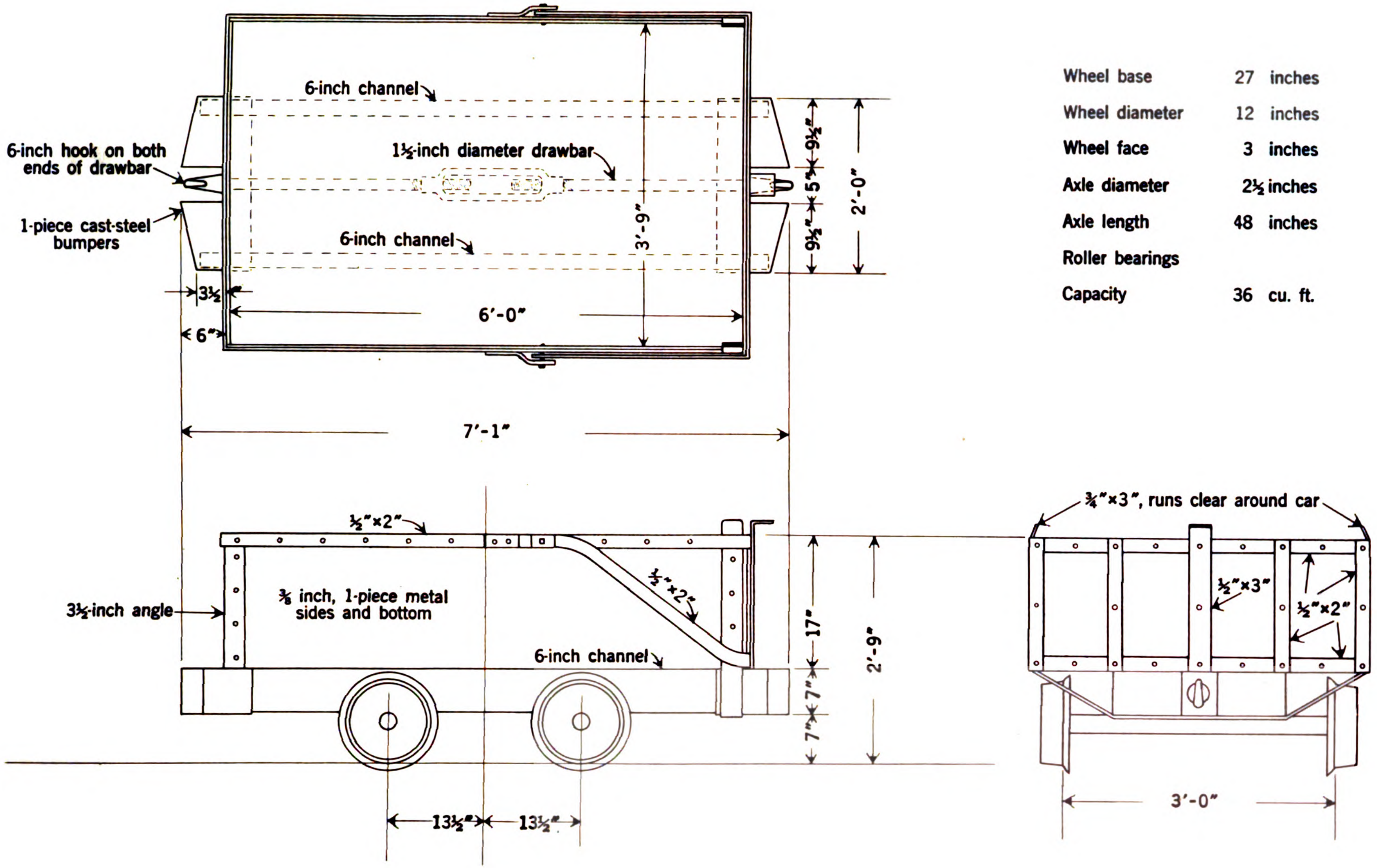
The round of holes in both face and bench will produce approximately 60 tons of broken gypsum. This is the equivalent of 0.430 pound of explosive per ton of gypsum. Blockholing or secondary blasting is seldom necessary.

Each driller is charged with the responsibility of firing his own round of holes unassisted, this being done at the end of the shift. Neighboring drillers keep in close touch with one another so that no accidents will occur when work is being done in adjoining rooms.

Loading

The broken gypsum is loaded by hand, 22 men being required to maintain the present tonnage. The loaders work in pairs, loading the gypsum into steel cars of 36 cubic feet or 2-1/2 tons capacity. They are paid at the rate of 15 cents per ton.

About 50 percent of the broken gypsum averages small enough to



Wheel base	27 inches
Wheel diameter	12 inches
Wheel face	3 inches
Axle diameter	2½ inches
Axle length	48 inches
Roller bearings	
Capacity	36 cu. ft.

Figure 6.—Mine car.

require shoveling, while the rest is lump material varying from 6- to 14-inch cubes. Each man will load an average of 25 tons of gypsum during an 8-hour shift.

The necessary tools, such as pick and shovel, are supplied by the men themselves.

Transportation

A single 8-ton trolley locomotive performs all the main-line hauling. This locomotive has an outside frame, being 13 feet long, 57 inches wide, and 32 inches high, and has 26-inch wheels mounted on 4-inch axles in a 40-inch wheel-base. It is powered by two centrally hung, 250-volt, 40-horsepower motors, each driving an axle through a pinion and gear. The rated draw-bar pull of the locomotive at a speed of 6 miles per hour is 4,000 pounds.

The trolley wire is "0000" grooved, suspended from the roof every 15 feet by means of suspension insulators set flush with and fastened into the roof by expansion sleeves. Careful bonding and cross-bonding of the rails insures a current of 250 volts throughout the mine.

The mine cars (fig. 6) are of all-steel construction, end-dump type, and have a capacity of 36 cubic feet. Twelve-inch wheels are mounted on 2-1/2-inch axles equipped with roller bearings, set on 27-inch wheelbase. The cars measure 7 feet overall and are 45 inches wide, and the body is 19 inches deep. They weigh approximately 2,000 pounds each and carry an average net load of 5,000 pounds. Seventy-five cars are in daily use.

Thirty-pound rails are used on the main line and service tracks. These are laid on 36-inch gage over untreated wood ties measuring 4 by 5 inches by 5 feet and spaced 24 inches apart. Nos. 2-1/2 and 3 frogs are used on room turnouts, while no. 3-1/2 frogs are used on the main haulage entries. The mine floor is usually smooth and level, so that excellent grades can be maintained easily with little grading and a minimum of ballast.

Two byes or sidings are maintained inside. The cars are distributed from these two points to the loaders by four mules, each mule serving five men. The locomotive train usually consists of 10 cars. The maximum haulage distance one way is 3,200 feet. The motorman is assisted by a brakeman, who rides on the locomotive.

The mules are brought to the surface at the end of each shift and stabled in a nearby building.

Timbering

Single, untreated, round posts are used to support the limestone roof. These are placed in two rows, parallel with and 2 feet from each rail, and are carried to within 10 feet of the working face. They are spaced on 10-foot centers, the posts of one row being staggered with those in the row opposite. Cap pieces are seldom used, the posts being fastened into position with hardwood wedges. The posts measures 6 inches minimum diameter on the small end and are from 5 to 7 feet in length. Oak, maple, elm, beech, and birch are the woods usually used. This timber is cut locally and averages 6-1/2 cents per linear foot delivered. The amount of timber used in 1936 amounted to 0.0722 linear foot per ton of gypsum mined. The posts will last from 12 to 15 years.

Pumping

An unusually large amount of water is pumped daily, but it is handled in such a manner that all the working places are dry at all times.

Five gathering pumps are used in the working faces. These pumps discharge to one of four centrifugal pumps, which, in turn, send the water to the surface. These centrifugal pumps are placed at strategic points in the old mine workings adjacent to low areas that serve as the collecting points or sumps. Each pump discharges to the surface through a borehole drilled for this purpose. Two of these boreholes are 6 inches in diameter, while two are 4 inches. The water handled is noncorrosive, so that plain cast-iron pipe is used, while the pumps themselves are unlined.

An average of 1,300,000 gallons of water is discharged to the surface daily, requiring the services of two pump men, one working 8 hours and the other 10 hours. The amount of water handled in 1936 was equal to 5,350 gallons per ton of gypsum mined. The size and capacity of the various pumps are as follows:

Type	Size		Type drive	Motor			Rated cap., g.p.m.	Discharge to-
	Suction	Discharge		Current	H.P.	R.p.m.		
Single-stage centrifugal	3" side	3" top	Belt, 6" x 11'-10"	A.C.	5	870	200	Surface
Single-stage centrifugal	3" side	3" top	Belt, 6" x 8'-5"	D.C.	12	1,800	300	Surface
Single-stage centrifugal	5" bottom	5" bottom	Direct	A.C.	35	1,760	600	Surface
Two-stage centrifugal	5" bottom	5" bottom	Direct	A.C.	30	1,740	600	Surface
Single-stage centrifugal	2" side	2" top	Direct	D.C.	5	1,700	200	Inside mine
Single-stage centrifugal	4" side	4" top	Belt, 6" x 9'-0"	A.C.	10	1,750	400	Inside mine
3" triplex--	5" x 8"	Cylinders	6" x 8'-0"	A.C.	7-1/2	865	125	Inside mine
3" triplex--	5" x 8"	Cylinders	6" x 8'-2"	A.C.	7-1/2	865	125	Inside mine
3" triplex--	5" x 8"	Cylinders	6" x 7'-6"	D.C.	10	850	125	Inside mine

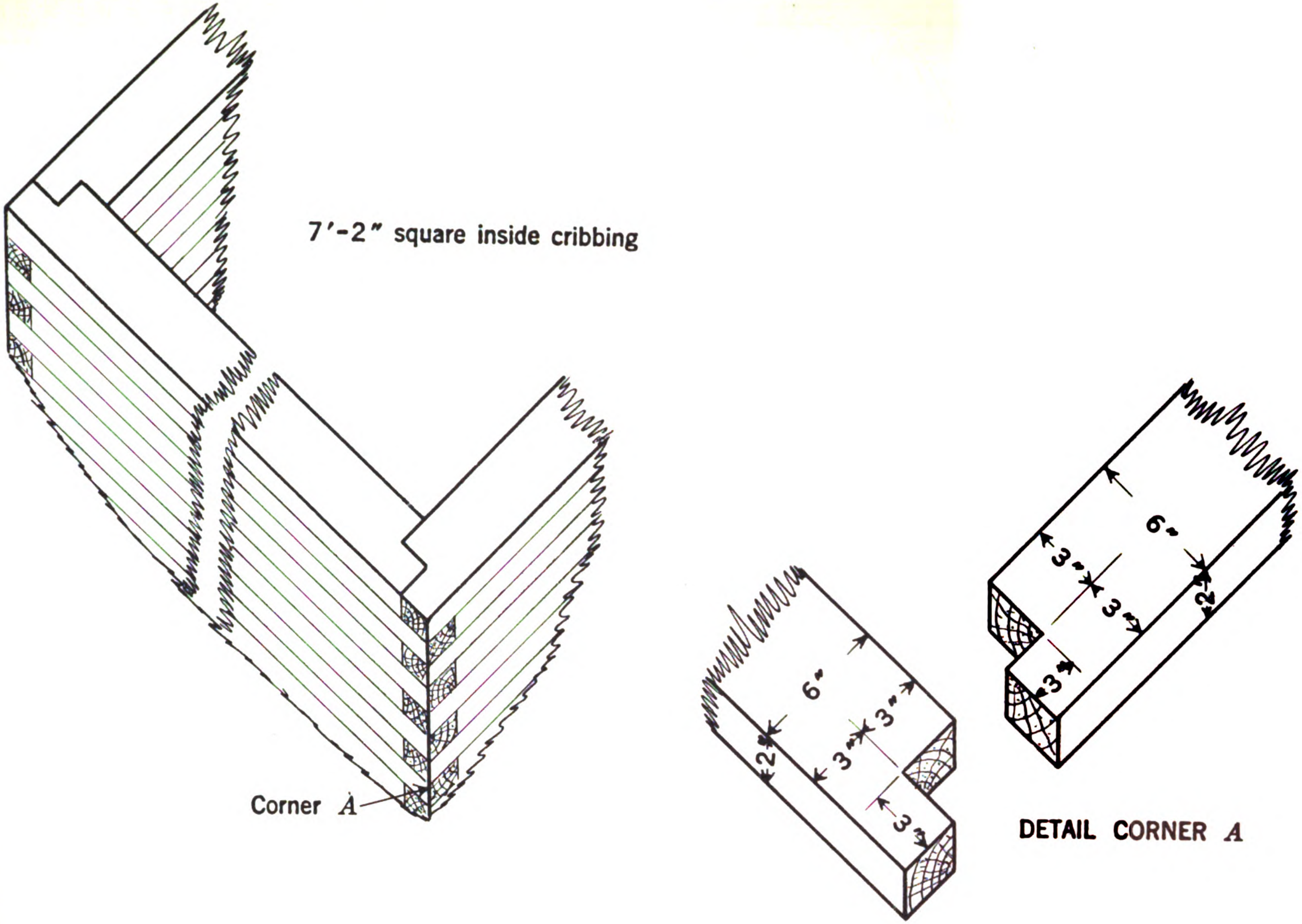
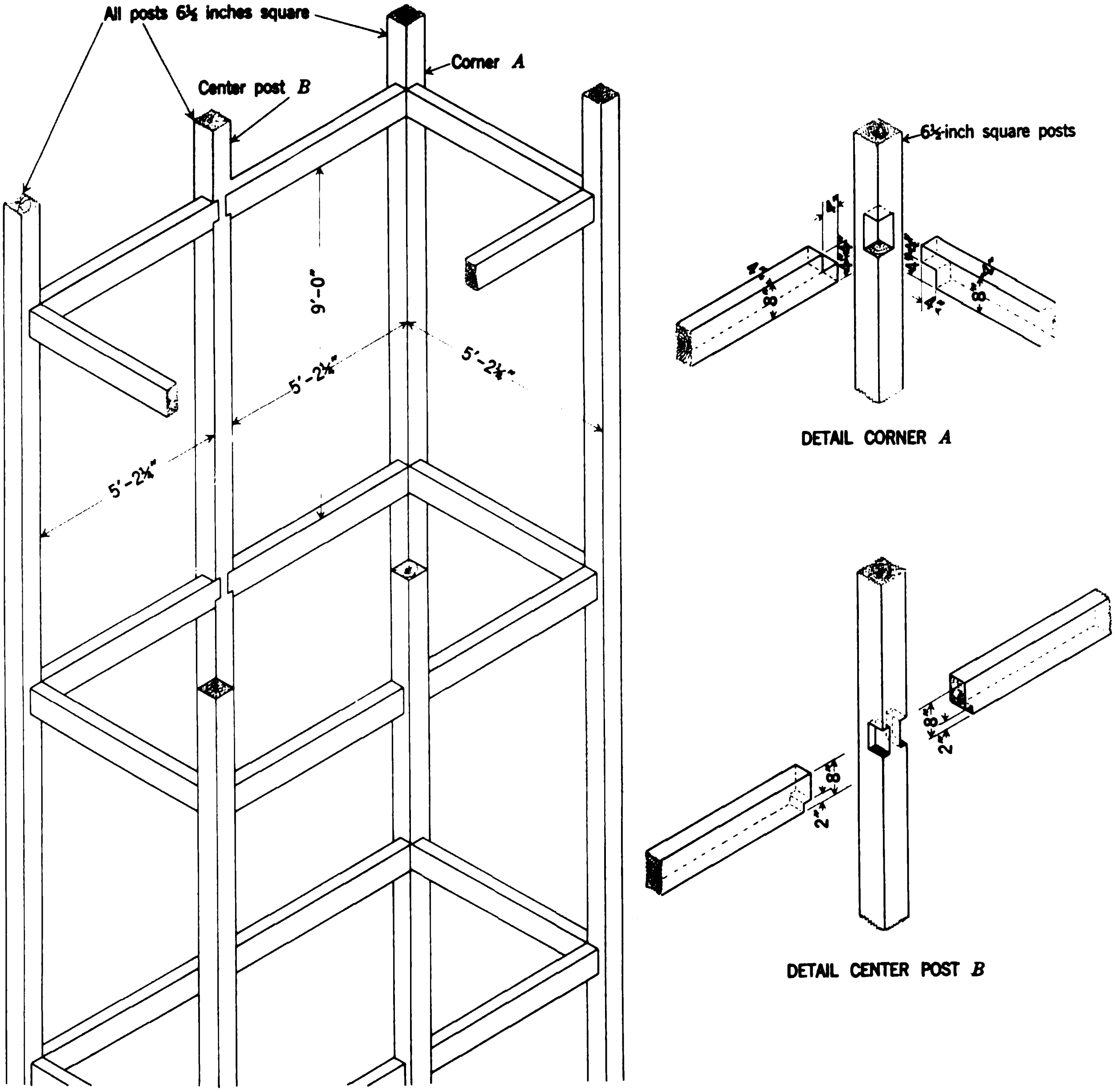


Figure 7a.—Air-shaft cribbing.



DETAIL CORNER *A*

DETAIL CENTER POST *B*

Figure 7b.—Air-shaft timbering.

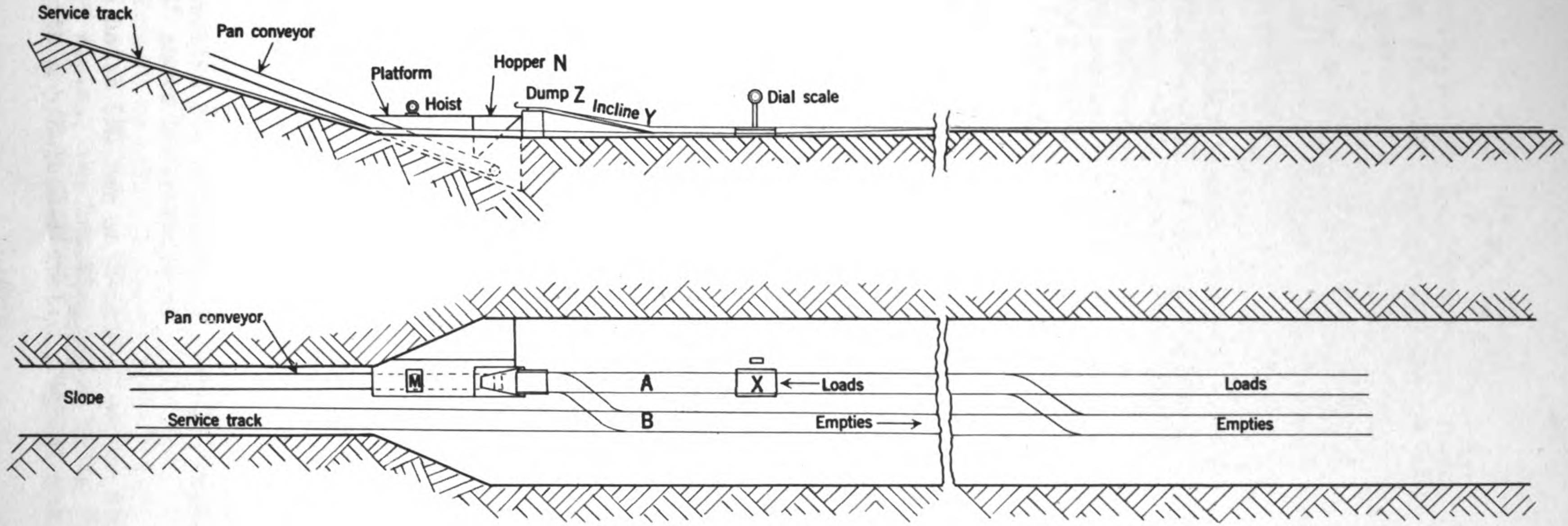


Figure 8.—Layout of slope bottom.

Ventilation

The ventilating system includes three vertical shafts. The first of these is about 200 feet east of the mine entrance and serves as the downcast. This shaft is 45 feet deep, 7 feet 2 inches square inside the cribbing, and is lined with 2- by 6-inch lumber, placed flatwise, to a point 15 feet below the collar. It was sunk from the surface in a comparatively short time. Figure 7a is a sketch showing the method used in placing the cribbing.

A fireproof building placed directly over the collar of this shaft houses the ventilating fan. This is a multiblade fan, 52 inches in diameter by 30 inches wide, having side suction and bottom discharge. It is capable of delivering 45,000 cubic feet of air per minute turning at a speed of 300 r.p.m. It is driven through a rubber transmission belt, 8 inches by 9 feet 2 inches long, by a 440-volt, 50-ampere, 60-cycle, 3-phase, 40-horsepower motor traveling at 860 r.p.m.

The remaining two vertical shafts serve as upcasts and escapeways. Both were sunk from the surface, are concrete lined throughout, and measure 12 feet square by 82 feet and 85 feet deep, respectively. A stairway 24 inches wide is the avenue of escape. The stairway is carried on a wood framework with 6-inch-square vertical members running from the bottom to the collar and 4- by 8-inch horizontal members. Figure 7b shows the method employed in framing these timbers.

A fireproof building 14 feet square is placed directly over each shaft. The upcast air is exhausted through an opening in the east side of the building immediately under the roof.

Slope Bottom

Figure 8 shows the layout of the slope bottom. The loaded cars arrive on the right-hand track (A), are weighed on the automatic dial scale (X), and then are pulled by a small hoist (M) up a short incline (Y) onto a horn dump (Z), whence they are dumped into the steel hopper (N). The empty cars are returned to track (B), made into 10-car trains, and returned inside. Two men are stationed at the bottom to perform the necessary weighing, hoisting, dumping, and shifting of cars.

The scale (X) has a steel platform 48 inches wide by 22 inches long. Both tare and capacity beams are provided. The net weight is registered instantly on a 30-inch dial indicator graduated from 20 to 5,000 pounds.

The short incline (Y) measures 15 feet in length and is pitched at an angle of 8° above horizontal.

The incline hoist (M) has an 8-inch-diameter drum 12 inches long and turning at 35 r.p.m., the hoisting speed being 75 feet per minute. It is equipped with a 5/8-inch-diameter, regular-lay, 6 by 19, plow-steel cable 300 feet long, whose life is approximately 2 years. The hoist is driven through a 6-inch by 7-foot 4-inch rubber transmission belt by a 440-volt, 13¾-ampere, 60-cycle, 3-phase, 7.5-horsepower motor traveling at 860 r.p.m. This hoist moves the loaded car trains to the slope bottom, thus necessitating the 300-foot cable.

The loaded trains coming from inside are brought to rest at a point 200 feet from the slope bottom. The locomotive is uncoupled, crosses over to the empty car track, and moves forward to couple onto the empty car train. The hoist cable is coupled to the end car of this empty train and is pulled forward by the locomotive until it reaches the loaded train, when it is coupled to the first car. The loaded train is then pulled by the hoist to the bottom.

The horn dump (Z) is 44 inches wide and 50 inches long and is placed 20 inches behind the curved rail of the horn. (See fig. 9.)

Hoisting

The gypsum falls by gravity from the steel hopper directly upon a pan conveyor that discharges into the crusher located on the ground floor of the mill. This conveyor is 136 feet on centers and is set at an angle of 20° above the horizontal. It is equipped with pans measuring 10 by 24 inches mounted on 3-1/2-inch-diameter, single-flange, cast-steel wheels pitched at 10 inches. Head and tail sprockets measure 22 inches in diameter and turn at 6 r.p.m. The capacity of the conveyor traveling at a speed of 36 feet per minute is 75 tons per hour. It is driven through a triple reduction drive by a 440-volt, 55-ampere, 60-cycle, 3-phase, 25-horsepower motor traveling at a speed of 860 r.p.m. The first reduction from the motor is through a silent chain drive, while the second and third reductions are through cut spur gears.

Miscellaneous

A fireproof building, 16 by 20 feet, situated on the surface near escape shaft no. 1, houses a motor-generator set that provides direct current for the mine. This set consists of a 440-volt, 130-ampere, 60-cycle, 3-phase, 112-horsepower motor direct-connected to a 75-kw., 250-volt, 300-ampere, compound-wound generator. The unit travels at a speed of 860 r.p.m. It supplies direct current for the haulage motor, the electric drills, and several pumps, the latter units necessitating 24-hour operation.

A blacksmith and car-repair shop and an electric shop are maintained underground approximately 150 feet from the foot of the slope. The blacksmith shop is equipped with a forge, drill press, power saw, and emery wheels. The blacksmith spends about 4 hours daily sharpening drill steel, 2 hours on car repair, and 2 hours on miscellaneous repair work.

The electrical shop is equipped to take care of all major repairs

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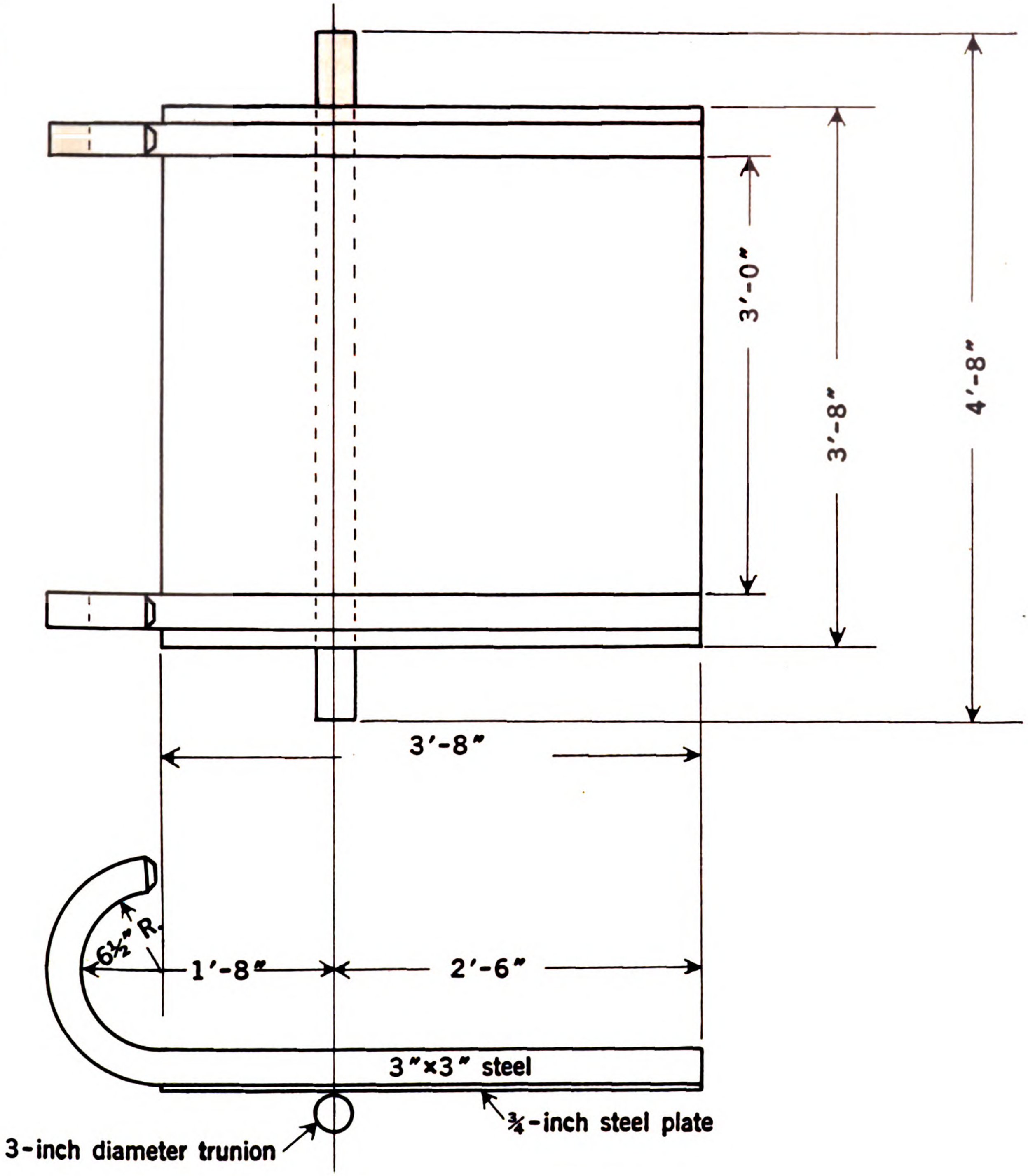

Figure 9.—Horn dump.

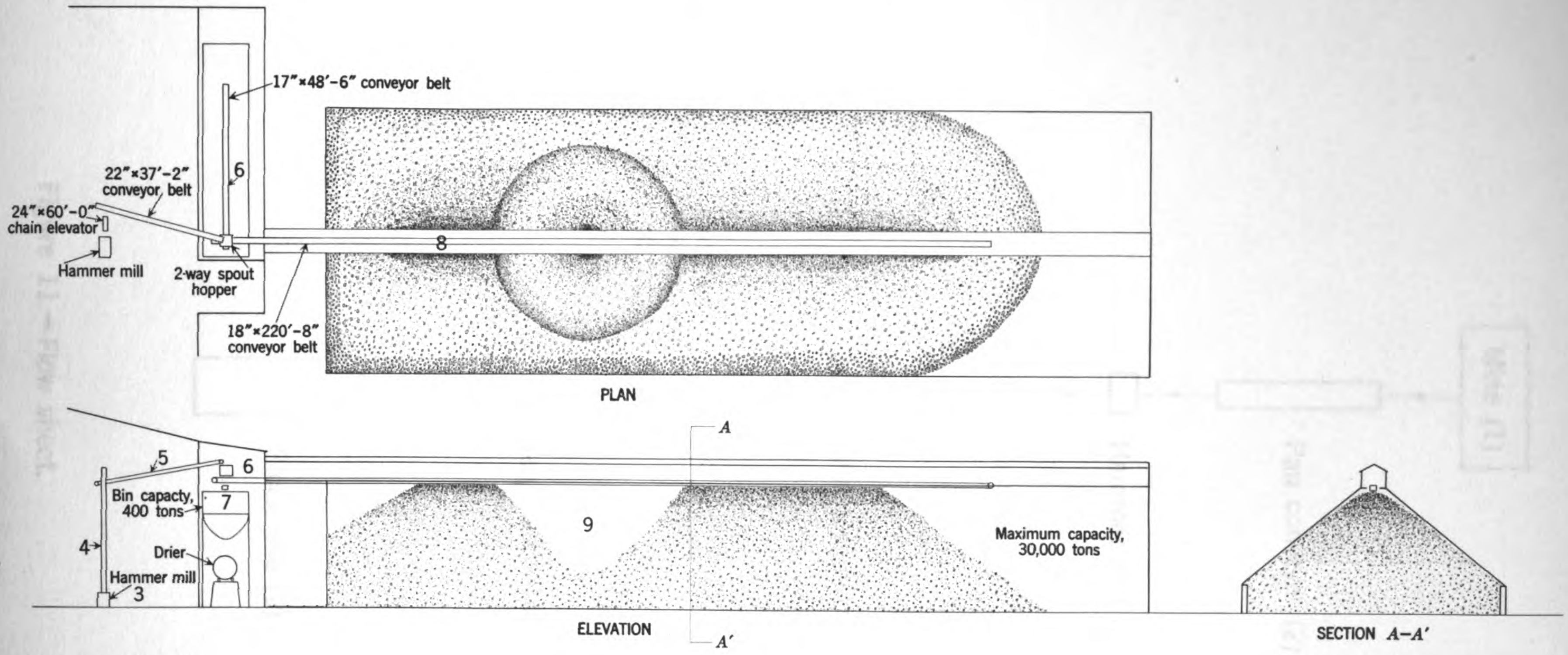

Figure 10.—Plant layout–stock pile.

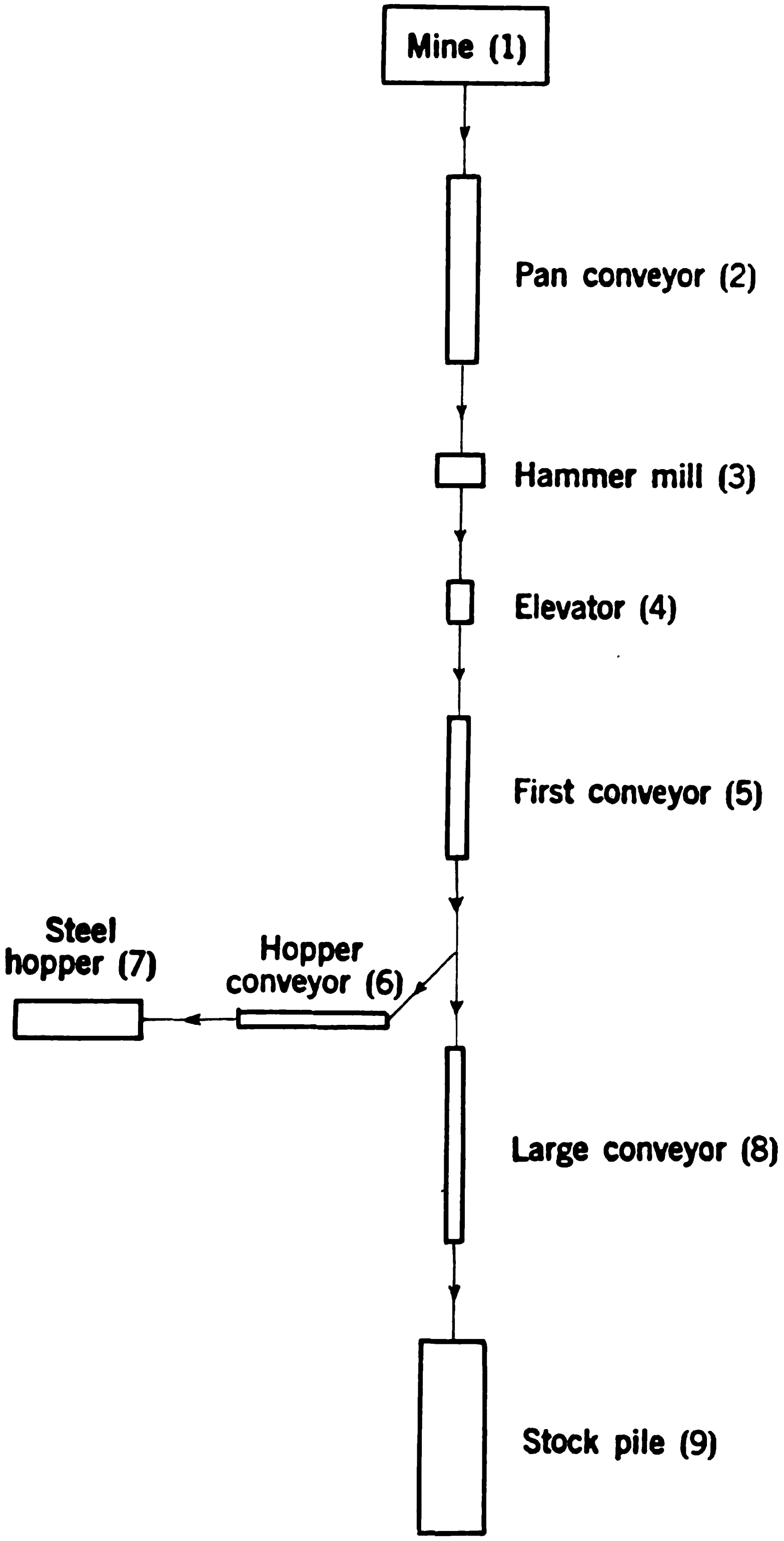

Figure 11.—Flow sheet.

to the electric drills and small motors. One electrician is required to take care of all electric repairs and maintenance.

The main slope hoist is about 15 feet from the top of the slope alongside the crusher. This hoist has a single cone-friction drum 16 inches in diameter by 26 inches long and turning at 26 r.p.m., the hoisting speed being 106 feet per minute. The hoist cable is 7/8 inch in diameter, 6 by 19, regular-lay, plow steel, 250 feet in length, and its life is usually about 3 years. The hoist is driven through a 5-inch by 6-foot 5-inch rubber transmission belt by a 440-volt, 12.5-ampere, 60-cycle, 3-phase, 10-horsepower motor traveling at a speed of 690 r.p.m. The hoist operates only a few minutes each day when supplies are taken below.

CRUSHING PLANT

Figure 10 shows the crushing plant and storage layout. Figure 11 is a flow-sheet covering the following operations.

Crushing

Primary crushing is performed with a single hammer-mill (3).[6] This machine is equipped with 30 special steel hammers measuring 2 by 4-1/2 by 13 inches, mounted on the rotor in six rows, and its capacity is 125 tons per hour. The cage is adjusted so that the crusher delivers a 2-inch maximum size product. It is direct-connected through a flexible coupling to a 440-volt, 143-ampere, 60-cycle, 3-phase, 125-horsepower motor traveling at a speed of 690 r.p.m.

The gypsum coming from the mine on the pan conveyor (2) is discharged over a short steel chute and falls directly into the hammer-mill. The crushed product then falls to the boot of the bucket elevator alongside.

Elevating

The elevator (4) is of the continuous bucket type having buckets that measure 8 by 9 by 24 inches mounted on a double-strand chain. It is set vertical on 60-foot centers and is steel-enclosed. Its capacity, traveling at a speed of 85 feet per minute, is 130 tons per hour. It is driven through a triple reduction drive by a 440-volt, 19-ampere, 60-cycle, 3-phase, 15-horsepower motor traveling at 860 r.p.m. The first reduction from the motor is through an 8-inch by 10-foot 10-inch rubber transmission belt, while the second and third reductions are through cut-spur gears.

Conveying--Storage

The product from the elevator is discharged upon a 22-inch belt conveyor (5) set at an angle of 8° above the horizontal on 37-foot 2-inch centers. The head pulley is 18 inches in diameter with a 25-inch face and travels at 50 r.p.m. The belt runs over one-piece steel, troughed-shaped idlers 10 inches in diameter on the large end, spaced on 54-inch centers. The capacity of the belt, traveling at a speed of 230 feet per minute, is 150 tons per hour. It is driven through a double reduction drive by a 440-volt, 27.1 ampere, 60-cycle, 3-phase, 5-horsepower motor traveling at a speed of 870 r.p.m. The first reduction from the motor is through a 6-inch by 5-foot 6-inch rubber transmission belt, while the second reduction is through cut-spur gears.

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[6] Numbers refer to flow-sheet, figure 11.

The belt discharges into a two-way spout hopper, so that the material can be sent either into the steel storage bin (7) or to the large storage pile (9).

A concentric lifting magnet is used to remove any tramp iron from the material. This magnet is 22 inches in diameter and is suspended 5 inches above the belt at a point 15 feet in front of the two-way spout hopper.

The distributing conveyor belt (6) over the steel storage bin is 17 inches wide and sets horizontally on 48-foot 6-inch centers. Head and tail pulleys are 24 inches in diameter with a 20-inch face and travel at 40-r.p.m. The capacity of the belt, traveling at a speed of 250 feet per minute, is 125 tons per hour. Two pulley troughing idlers, 5 inches in diameter and with an 8-inch face, are spaced on 58-inch centers. These idlers are mounted on a tilting steel frame so that any section of the belt can be made to discharge its material wherever desired in the bin beneath.

The belt is driven through a triple reduction drive by a 440-volt, 6.35-ampere, 60-cycle, 3-phase, 5-horsepower motor traveling at 860 r.p.m. The first reduction from the motor is through a 6-inch by 6-foot 2-inch rubber transmission belt, while the second and third reductions are through cut-spur gears.

The steel storage bin (7) is of the bunker type, having a curved bottom. The bin is 61 feet long, 16 feet wide, and 16 feet high over all, and has a capacity of 400 tons of crushed gypsum. The lowest point of the bin is 20 feet above the floor and directly over the horizontal cylindrical dryer.

The conveyor (8) that handles the crushed gypsum to the large storage shed (9) is 18 inches wide, placed horizontally on 220-foot 8-inch centers, and 38 feet above the ground elevation. The first 60 feet of the belt runs over three pulley troughed idlers 6 inches in diameter and with an 8-inch face spaced on 58-inch centers. The rest of the conveyor runs over idlers of identical size and spacing mounted on tilting steel frames, which permit the discharge of the crushed gypsum at any point along the storage space. Head and tail pulleys are 24 inches in diameter with a 20-inch face and travel at

60 r.p.m. The capacity of this belt, traveling at a speed of 350 feet per minute, is 175 tons per hour.

The belt is driven through a double reduction drive by a 440-volt, 918-ampere, 60-cycle, 3-phase, 7.5-horsepower motor traveling at a speed of 860 r.p.m. The first reduction from the motor is through a 6-inch rubber transmission belt, while the second reduction to the drive shaft is through cut-spur gears.

The large storage pile (9) is roughly 230 feet long and 72 feet wide at the base and 36 feet high and has a capacity of 30,000 tons of crushed gypsum. It is entirely enclosed in a steel and concrete building. The side walls of the building are constructed of concrete and are 2 feet thick and 9 feet high. The rest of the building is constructed of corrugated iron placed on structural steel, the roof being immediately above the surface of the crushed gypsum and pitched at an angle of 35°, this being the angle of repose of the material itself. Figure 10 shows side and end views of this storage building.

Power

Electric power for both the mine and the entire manufacturing plant is purchased from the Niagara and Hudson Power Co. on a sliding-scale basis, the rate averaging $0.011 per kw.-hr. The total actual kw.-hr. consumed during 1936 was approximately 602,737, or the equivalent of 6.706 kw.-hr. per ton of gypsum mined. An analysis of the power requirements follows:

Unit	Rated Kw.-hr.	Consumed Kw.-hr.	Kw.-hr. per ton	Total cost	Cost per ton
Mine:					
Drilling	72,800	14,560	0.162	$ 160.00	$0.0018
Transportation	43,680	10,800	0.120	118.00	0.0013
Pumping	1,506,720	426,981	4.760	4,696.80	0.0522
Hoisting	61,172	17,290	0.193	180.00	0.0020
Miscellaneous	530,000	43,200	0.481	485.20	0.0054
Total mine	2,214,372	512,831	5.716	5,640.00	0.0627
Crushing plant:					
Crushing	135,408	85,540	0.052	940.00	0.0105
Elevating	16,380	2,000	0.022	22.00	0.0002
Conveying	18,564	2,366	0.026	36.00	0.0003
Total plant	170,352	89,906	1.000	988.00	0.0110
Grand total	2,384,724	602,737	6.716	6,628.00	0.0737

All the employees live nearby and the labor turnover is relatively small. The labor is classified as follows:

Classification	Number of men
Productive:	
Drillers	11
Loaders	22
Motorman	1
Brakeman	1
Mule drivers	4
Nonproductive:	
Track	4
Timbermen	1
Pumpmen	2
Blacksmith	1
Electrician	1
Cager	1
Weighman	1
Crusherman	1
Elevating-conveying	1
Miscellaneous	1
Total	53

PERCENT EXTRACTION

The mining recovery at present is approximately 80 percent. The remaining 20 percent can be recovered later by removing pillars on a retreating system.

The crushing plant delivers the same tonnage it receives from the mine, there being no loss due to fines or impurities.

The various manufacturing units of the plant consume about three-fourths of the mine output, the balance being sold to the cement industry as crushed gypsum.

EMPLOYEE PAY SYSTEM

The mine operates on a single 8-hour shift. The working season varies slightly owing to the decline of building during the winter months. However, 10 months or approximately 225 days constitute a good average year at present.

The drillers and loaders are paid on a contract or tonnage basis, the rates being 20 and 15 cents per ton, respectively. The remaining employees are all paid on an hourly basis, the rate averaging 40 cents per hour.

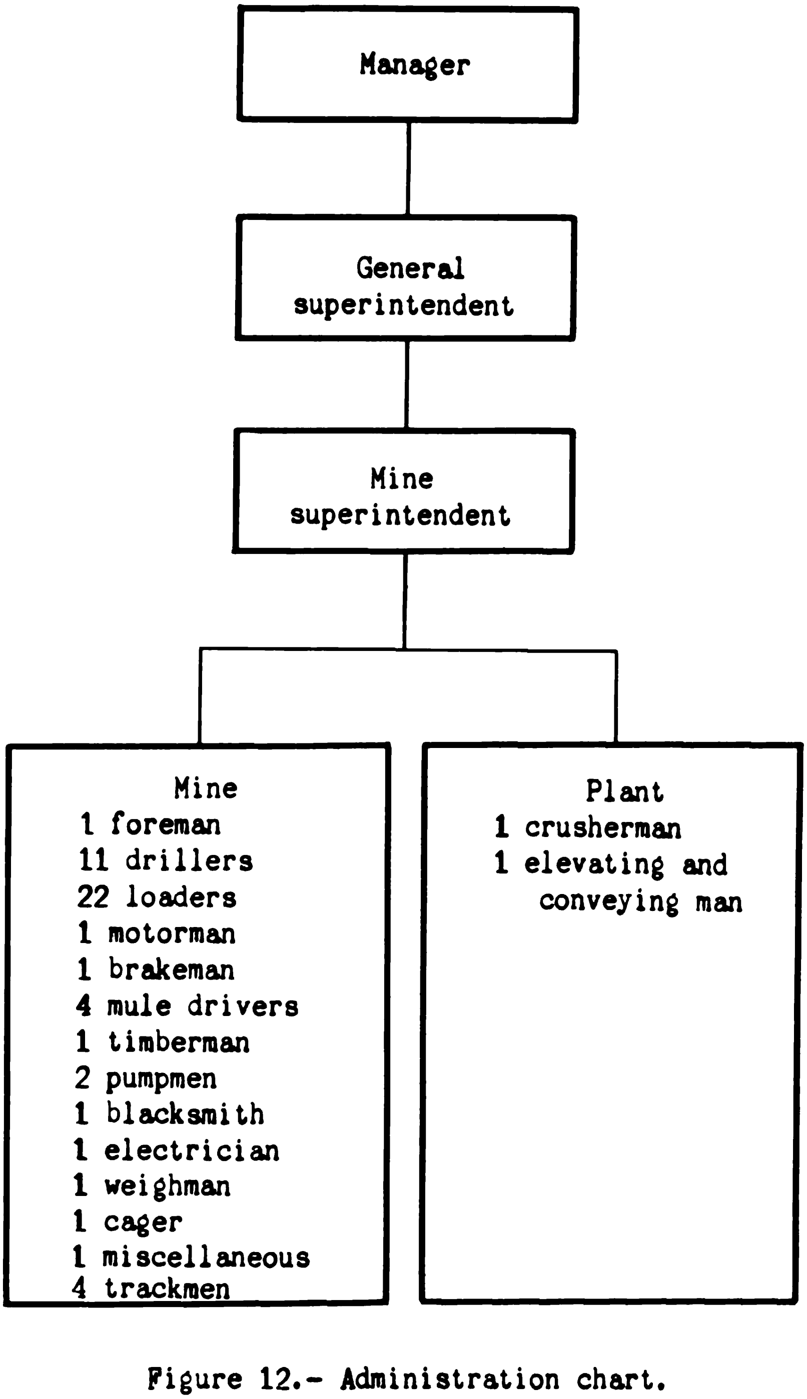

Figure 12.- Administration chart.

SAFETY METHODS AND FIRST-AID ORGANIZATION AND TRAINING

Well equipped first-aid cabinets are maintained for the treatment of minor injuries. Army stretchers are kept in the mine ready for instant use.

Explosives are handled only by experienced drillers. The working faces are always timbered to within 10 feet of the face. The low roof is easily watched, and ample supervision is maintained at all times.

The surface plant is of the latest type steel and concrete construction, well lighted, and kept clean and orderly. Proper safety guards are maintained on all machines and at hazardous points.

Well lighted bulletin boards are placed at strategic points, and the latest safety bulletins are kept posted.

In 1929, the entire personnel of the mine was given a course in first-aid training by an instructor from the safety division of the U. S. Bureau of Mines.

FORM OF ADMINISTRATIVE ORGANIZATION

Figure 12 is an organization chart of the mine and crushing plant. The mine superintendent has full authority over both operations and reports directly to the general superintendent.

I. SUMMARY OF COSTS

Name: Ebsary Gypsum Co., Inc.
Period covered: 1936
Total tons gypsum mined: 89,941

Classification	Labor	Supervision	Air drilled steel	Power cost	Explosives	Other Supplies	Total
Drilling	$0.1539		$0.0036	$0.0018		$0.0081	$0.1674
Blasting	.0500				$0.0667		.1167
Loading	.1499						.1499
Transportation	.0842			.0013		.0138	.0993
Timbering	.0065					.0047	.0112
Pumping	.0224			.0522		.0010	.0756
Hoisting including pan conveyor	.0163			.0020		.0105	.0228
Miscellaneous	.0011	$0.0265		.0054		.0008	.0339
Total mine	.4843	.0265	.0036	.0267	.0667	.0389	.6828
Crushing	.0076			.0105			.0181
Conveying	.0040			.0003			.0043
Elevating	.0032			.0002			.0034
Miscellaneous	.0011	.0029				.0008	.0048
Total plant	.0159	.0029		.0110		.0008	.0306
Grand total	.5002	.0295	.0036	.0737	.0667	.0397	.7134

II. SUMMARY OF COSTS IN UNITS OF LABOR, POWER, AND SUPPLIES

Name: Ebsary Gypsum Co., Inc.
Period covered: 1936
Total tons gypsum mined: 89,941

Classification	Mining	Crushing	Other	Total
A. Labor (man hours per ton gypsum):				
Drilling-------------------------	0.1780			0.1780
Blasting-------------------------	.0450			.0450
Loading--------------------------	.3560			.3560
Haulage--------------------------	.1780			.1780
Timbering------------------------	.0160			.0160
Miscellaneous--------------------	.1370	0.0160	0.0160	.1690
Total labor	.9100	.0160	.0160	.9420
Average tons per man shift	9.80	500.00	500.00	9.10
Labor, percent of total cost				74.25
B. Power supplies:				
Explosives (lbs. per ton)	0.430			.430
Timber (lineal foot per ton)	.072			.072
Total power (kw.hr. per ton):				
Drilling-------------------------	.162			.162
Locomotive-----------------------	.120			.120
Pumping--------------------------	4.760			4.760
Hoisting (Incl. man conveyor)----	.193			.193
Ventilation----------------------	.481			.481
Crushing-------------------------		0.952		.952
Elevating------------------------		.022		.022
Conveying------------------------		.026		.026
Other supplies in percent of total supplies and power				21.60
Supplies and power, percent of total cost				25.75

III. DETAILED SUMMARY OF MINE COSTS--DIRECT OPERATION

Name: Ebsary Gypsum Co., Inc.
Period covered: 1936
Total tons gypsum mined: 89,941

Classification	Amount	Cost per ton	Total unit cost
Loading	$13,491.15	$0.1499	$0.1499
Drilling:			
Operating labor	13,491.20	0.1500	
Power	160.00	0.0019	
Operating supplies	322.00	0.0033	
Repair labor	364.00	0.0041	
Repair supplies	722.00	0.0081	
Total drilling	15,059.20	0.1674	0.1674
Blasting:			
Labor	4,497.00	0.0498	
Explosives	6,022.00	0.0669	
Total blasting	10,519.00	0.1167	0.1167
Haulage:			
Locomotive	1,122.40	0.0125	
Mules	4,713.40	0.0524	
Cars	781.00	0.0086	
Track	2,329.60	0.0258	
Total haulage	8,946.40	0.0993	0.0993
Timbering:			
Labor	582.40	0.0065	
Supplies	422.50	0.0047	
Total timbering	1,004.90	0.0112	0.0112
General charges	12,458.43	0.1383	0.1383
Grand total	61,479.08	0.6828	0.6828